Experimental Report

Proposal: **4-01-1394** **Council:** 4/2014

Title: Approaching the bond-nematic quantum critical region in a 2D square lattice magnet

This proposal is continuation of: 5-53-228

Researh Area: Physics

Main proposer: **SKOULATOS MARKOS**

Experimental Team: SKOULATOS MARKOS
SCHMIDT Burkhard
SMERALD Andrew

Local Contact: OLLIVIER Jacques

Samples: BaCdVO(PO4)2

Instrument	Req. Days	All. Days	From	To
IN5	5	5	20/11/2014	25/11/2014

Abstract:

Frustrated square-lattice antiferromagnets with competing interactions J1 and J2 are prototypical model system to study complex magnetic correlations. For the generalised J1-J2 model including ferromagnetic interactions new spin-liquid and bond-nematic phases are predicted by theory. We have been able to synthesize the compound BaCdVO(PO4)2 and recently proved on D7 that it lies right on the border of a columnar antiferromagnetic phase with the spin-nematic phase. Here we propose to investigate the magnetic excitations of this unique material and characterize the nature of its quantum fluctuations. A way of driving this material right inside the spin-nematic phase is also described. As a future plan, this phase will then be accessible to us with the new 10T option of IN5 in the coming year.

EXPERIMENTAL REPORT

EXPERIMENT N°: 4-01-1394 INSTRUMENT: IN5

DATES OF EXPERIMENT: 20-25/11/2014

TITLE: Approaching the bond-nematic quantum critical region in a 2D square lattice magnet

EXPERIMENTAL TEAM:
M. Skoulatos, B. Schmidt and A. Smerald

LOCAL CONTACT: J. Ollivier

The frustrated square-lattice (FSL) S=1/2 Heisenberg antiferromagnet with nearest-neighbour exchange constant J_1 and next-nearest-neighbour exchange J_2, has long served as a paradigm for two-dimensional frustrated magnetism [1]. The so-called J_1-J_2 model first came to prominence due to its connection to the high-temperature superconducting cuprates. The more recent discovery of high-T_C superconductivity in pnictides [2,3] has increased interest in this model, since it may play a key role for the magnetism on the square Fe sublattice [4,5]. The frustrated square-lattice model is characterized by the frustration ratio α=J_2/J_1, and the energy scale is given by $J_c = \sqrt{J_1^2 + J_2^2}$. When the exchange constants are antiferromagnetic (AF) and $\alpha \approx 0.5$ the ground state is believed to be a valence bond solid in which spins form tightly bound singlets on nearest-neighbour bonds [6]. On the other hand, calculations for ferromagnetic (FM) J_1 and AF J_2 predict d-wave bond-nematic order for $\alpha \approx -0.5$ [7,8].

There are now several experimental realisations of spin-1/2 magnets on a square lattice where both J_1 and J_2 interactions play an important role [9], however only one material is known lying close to the so called spin-nematic region: $BaCdVO(PO_4)_2$ [10].

We studied the spin spectrum on IN5 as a function of wavelength and temperature at zero-field. Antiferromagnetic (AF) excitations were found at the lowest temperatures, with typical spectra shown in Fig. 1. These are background subtracted, corrected and normalised.

Having identified the ground state, we are in a position to drive the system with a magnetic field into the spin-nematic region. Theory predictions for this new phase exist and will enable us to handle the data correctly.

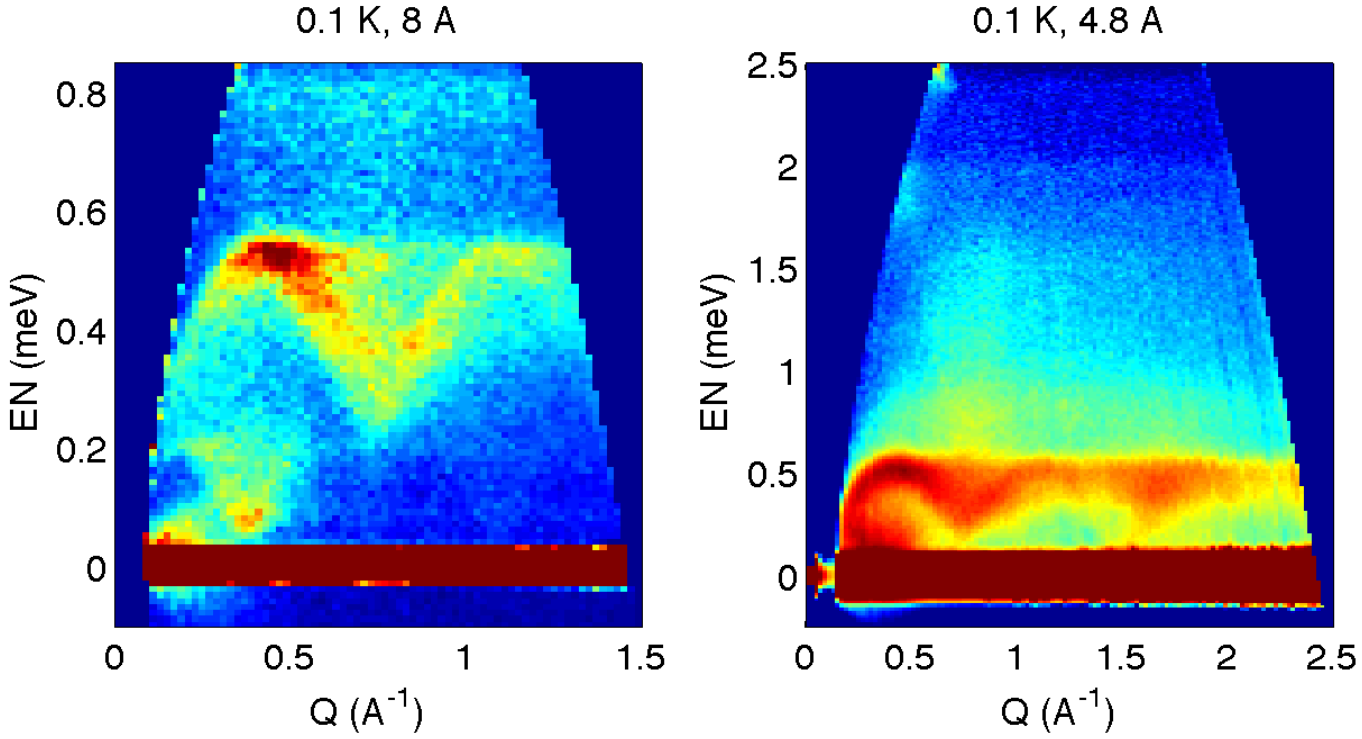

Fig. 1: Excitation spectrum of $BaCdVO(PO_4)_2$ at two different wavelength settings at zero-field. The system lies on the border of the spin-nematic phase, but still in the columnar AF region. With IN5 it was possible to measure these weak AF signals.

References:

[1] Misguich G. and Lhuillier C., Frustrated Spin Systems, edited by Diep H. T. (World Scientific, Singapore) 2004. [2] Y. Kamihara, T. Watanabe, M. Hirano and H. Hosono, J. Am. Chem. Soc. **130**, 3296 (2008). [3] X. Chen, T. Wu, G. Wu, R. Liu, H. Chen and D. Fang, Nature **453**, 761 (2008). [4] Q. Si and E. Abrahams, Phys. Rev. Lett. **101**, 076401 (2008). [5] A. Smerald and N. Shannon, Eur. Phys. Lett. **92**, 47005 (2010). [6] H. Schulz, T. Ziman and D. Poilblanc, J. Phys. I **6**, 675 (1996). [7] N. Shannon, B. Schmidt, K. Penc and P. Thalmeier, Eur. Phys. J. B **41**, 599 (2004). [8] N. Shannon, T. Momoi and P. Sindzingre, Phys. Rev. Lett. **96**, 027213 (2006). [9] M. Skoulatos, J.P. Goff, C. Geibel, E.E. Kaul, R. Nath, N. Shannon, B. Schmidt, A.P. Murani, P.P. Deen, M. Enderle and A.R. Wildes, Eur. Phys. Lett. **88**, 57005 (2009). [10] R. Nath, A.A. Tsirlin, H. Rosner and C. Geibel, Phys. Rev. B **78**, 064422 (2008).